HANDLING APPLES from tree to table

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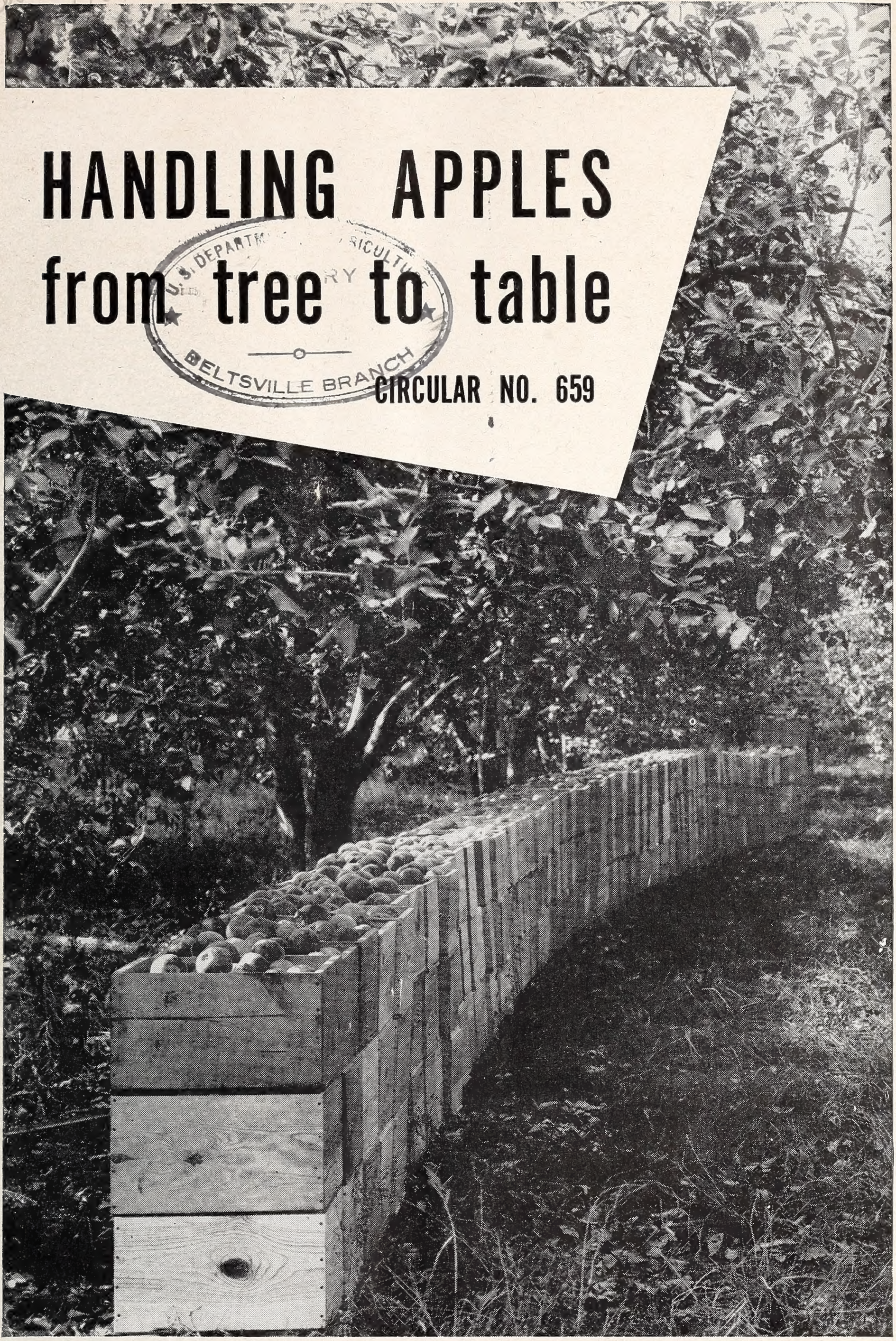

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UNITED STATES DEPARTMENT OF AGRICULTURE

Handling Apples From Tree to Table

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INTRODUCTION

The condition of apples in retail markets is sometimes disappointing to buyers. To the extent that it influences the demand for apples, such disappointment affects the market price of the fruit and the returns to the grower. Most important in this connection are the stage of ripeness of the fruit and its freedom from decay, bruises, and other injuries.

Growers who invest a season's work in pruning, fertilizing, spraying, and cultivating their orchards, with all the care and expense necessary to produce a clean crop of high-quality fruit, cannot help being disturbed by the poor condition of apples offered by retailers. This also constitutes one of the greatest handicaps to success of organizations established by the apple industry to advertise and otherwise promote the sale and use of apples.

[1] Died September 18, 1949.

Growers are inclined to place the blame for the lack of quality in the apples offered in grocery stores and other outlets on the retailers and other intermediaries in the merchandising chain. They feel that the handlers of the fruit are not "apple-minded"; that to them apples are just so much perishable merchandise to be handled and priced according to the risk attached; that, in the absence of knowledge on how to minimize the risks, the retail price of the fruit is often pyramided to a point at which sales are retarded and the whole industry suffers correspondingly; and that, consequently, customers, unable to buy the kind of apples that they would like, turn to competing fruits.

Market men, on the other hand, hold that frequently the fruit when received has already deteriorated so much that its value is greatly reduced and the hazards of further deterioration while in process of sale are greatly increased. Most retailers are no more interested in apples than in any other commodity that will yield the same profit; so, if there are unusual risks in handling apples, this fruit naturally will not receive the consideration that it otherwise would.

This circular gives the available information on how to handle apples from the time of harvest so that they will reach the ultimate consumer in prime condition, as well as the reasons for the recommendations. Need for this information is greater today than it was a few years ago, because of the increased production of apple varieties that are more susceptible to injury and deterioration during storage, transportation, and market distribution than many of the varieties formerly grown. Approximately 60 percent of the commercial apple production of the United States now consists of varieties having relatively soft flesh. Such important varieties as McIntosh, Golden Delicious, Cortland, Stayman Winesap, and Delicious and its red strains all are much more tender and more subject to injury in handling than are the hard-fleshed varieties like Winesap, Yellow Newtown, Baldwin, and York Imperial. While all varieties should be handled carefully, it is particularly important with the tender-fleshed varieties.

THE GROWER'S RESPONSIBILITY

In the business of placing good-quality fruit before the consumer it is the responsibility of the producer to grow a crop of good apples, rather than just a good crop of apples. It is axiomatic that the orchard must be properly pruned, sprayed, and cultivated to produce a profitable crop. Every successful orchardist, although alert for new ideas in apple culture, is already familiar with good cultural practices and is producing a certain proportion of good apples. Progressive growers constantly strive to increase the proportion of good apples as well as to increase the size of the crop.

When to Pick Apples

One of the principal causes of the poor condition of apples as they finally reach the consumer is failure to pick them at the proper stage of maturity. When picked too soon, apples fail to develop good eating quality and are very susceptible to certain functional diseases that develop later, particularly bitter pit and scald. When not picked soon enough, they do not stand up well in storage and are subject to other functional diseases that often cause serious losses in storage, especially

soft scald and internal breakdown. The reason for the failures is that the apple is a living organism with a more or less definite potential span of life. If it lives too fast, either before or after picking, its vitality is exhausted prematurely, and the time it remains in good eating condition is shortened proportionately.

While attached to the tree the apple is part of the tree and is influenced by any factors that affect the growth of the tree. When the tree suffers from drought, for example, the apple responds by slowing down its rate of growth; when the tree is so stimulated that it makes abnormally fast growth, the fruit grows vigorously and may become overgrown and punky. As the fruit grows it accumulates the constituents which finally characterize a mature apple. Not all of the constituents are accumulated at the same rate; only at maturity is the final balance reached. As the apple grows the fleshy part becomes essentially a reservoir for the materials upon which its potential storage life depends. These are chiefly carbohydrates, malic acid, water, small amounts of aromatic materials highly important in giving flavor, and vitamins and minerals important for dietetic value. As the apple approaches maturity it continues to increase in size but loses acidity and increases in sweetness, with the conversion of starch into sugar. Ripening may occur either before or after harvest and is accompanied by a softening of the flesh and an increase in juiciness and aroma.

A relatively small proportion of the sugar in the apple is used in respiration, being broken down to carbon dioxide and water, which are given off to the atmosphere. The acidity is, however, reduced to a much greater extent during ripening than is the sugar; and, in addition, the aromatic materials are gradually lost by volatilization. The taste becomes progressively more insipid and less desirable as the apple is held beyond its normal storage season. Everyone knows that if an apple is left on the tree or held in storage too long it becomes mealy, flavorless, and soft. When the life processes of the fruit are carried so far that pectic materials finally dissolve out of the cell walls, permitting the cells to separate easily, the mealiness that characterizes overripe apples is produced. What remains at the end is an apple in the last stages of senility, entirely unsuitable for market and undesirable for either culinary or dessert use. Therefore, although the fruit must become mature before harvest to develop best quality, the ripening for the most part should come after harvest to insure long storage and good market quality.

Criteria of Maturity

Criteria of maturity for apples have included ease of separation of the fruit from the spur, fruit color and appearance, period from full bloom, firmness of the fruit, and certain tissue characteristics (*9*).[2] None of these is entirely dependable under all conditions.

EASE OF SEPARATION FROM THE SPUR

When an apple is ready to pick, it can be separated from the spur without breaking the stem merely by lifting it in the hand with or without a slight rotating movement. As the attachment of the fruit to the

[2] Italic numbers in parentheses refer to Literature Cited, p. 42.

spur is like a hinge, picking should be an unhinging process. Inexperienced or careless pickers, however, often pull the fruit from its attachment. This usually results in breaking the spurs, which cuts down the bearing surface and reduces succeeding crops, or in pulling out the stem of the apple and tearing the flesh, thus opening the way to decay.

Ease of separation is not a reliable index of maturity (*10*). Under some conditions apples start to drop before they are properly mature. Then they may be harvested before becoming sufficiently mature to develop the best quality after ripening. Harvest sprays, such as naphthaleneacetic acid, which have come into rather general use to prevent fruit drop in some sections (*1*), invalidate the ease of separation from the spur as a criterion of maturity. Although these sprays make the fruit stay on the tree longer, they do not interrupt the advance of maturity; and as a result of their use picking may be delayed until the fruit is overmature.

FRUIT COLOR AND APPEARANCE

The blush, or red color, of an apple is not a reliable index of maturity. The ground color (underlying green or yellow), however, can be used as an index. The quality of a red apple can be judged ordinarily by the proportion of red to green; the more red, the better the eating quality. As most varieties of apples become mature the ground color changes from a green very much like that of the leaves to a lighter shade and eventually to yellowish. The time to pick most varieties is when the first signs of yellowing appear (*9*). This is not always true with some varieties—Grimes Golden, Jonathan, and Yellow Newtown, for example—when grown under certain conditions. The red sports of some varieties usually become fully red before they are mature, with no underlying ground color left for observation. As a result, they have frequently been picked too soon and have suffered in popular esteem because they were judged to have poorer quality than the parent variety. Although ground color cannot be used as an index of maturity for red bud sports, the ground color of the parent varieties growing in the same vicinity can be so used, as their seasons of maturity are ordinarily about the same.

As fruit matures on the tree it develops a waxy coating and the lenticels, or pores in the skin, become sealed with cork. These changes, however, are not sufficiently discernible with most varieties to make them of much value in determining when the fruit should be picked.

PERIOD FROM FULL BLOOM TO MATURITY

The number of days from full bloom to picking maturity has been found to be rather constant over a wide range of climatic and cultural conditions, hence very helpful in determining when the crop should be picked (*10*). The method requires the keeping of records showing the dates of full bloom of varieties in a given orchard. This is the date when the first petals fall without the influence of strong wind, or when most of the basal blossoms in a cluster have opened. When warm weather that brings the center, or king, blossom into full bloom is followed by cool weather that retards the opening and pollinating of the other blossoms for a week or more, establishing the date of full bloom for most

of the fruit that sets is subject to error. The time of maturity of different fruits on the same tree may vary decidedly.

The number of days from full bloom to maturity for the varieties on which a long-time study has been made in different sections of the United States (*10*) is shown in figure 1. The middle part of each bar

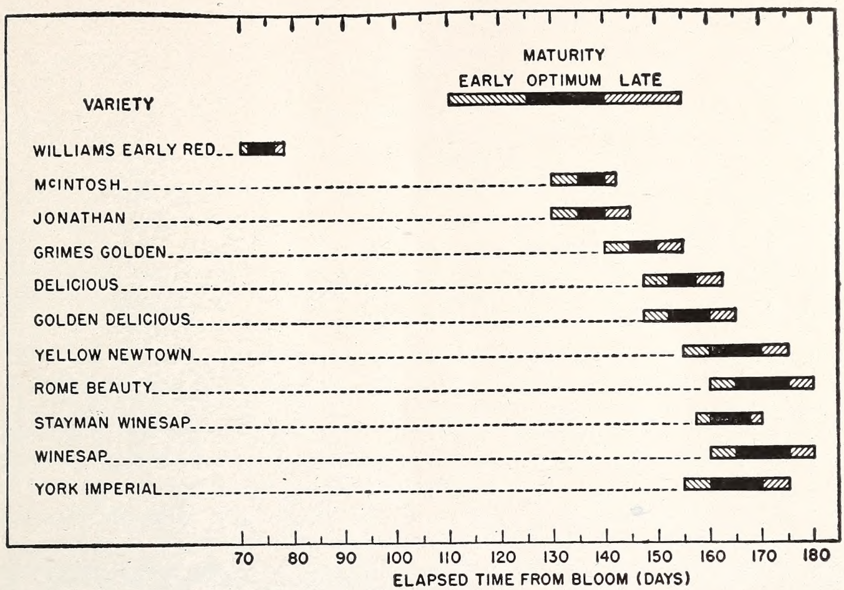

FIGURE 1.—Days elapsing from bloom to maturity. For meaning of different parts of bars, see text.

represents the period when the fruit will be at optimum maturity for best dessert and storage qualities. Variations from these periods occurred during certain seasons in different regions; the most obvious reasons for them being variations in the volume of the crop, such as light crops that mature in fewer days and heavy crops that require a greater number of days after full bloom. In certain instances an unusually early blossoming season with cool weather during the first month thereafter was followed by a longer than average period to time of maturity, whereas a very late blossoming season with optimum growing conditions thereafter has been known to shorten the period to optimum maturity by nearly a week.

FIRMNESS AS DETERMINED BY THE PRESSURE TEST

Firmness, as indicated by the pressure test, has not been found to be a reliable index for determining when apples acquire satisfactory maturity for picking (*10*). Measuring firmness with the pressure tester, however, is useful in determining when apples are becoming overmature and too soft for storage.

As apples approach maturity they become progressively less resistant to pressure, a characteristic which makes it possible to utilize mechanical means of measuring the rate of softening. Several types of pressure

testers have been devised. The one most commonly used is that developed by Magness and Taylor (*17*), which measures the pressure required to force a plunger seven-sixteenths of an inch in diameter into the flesh of the apple to a distance of five-sixteenths of an inch after paring off the skin. Haller (*7*) has presented the results of a long series of investigations on the use of the pressure test on apples and other fruits. Pressure-test records have been transposed into the ordinarily accepted commercial designations of "hard," "firm," "firm ripe," and "ripe" by Haller, Lutz, and Mallison (*8*). The foregoing publications give details on the application and limitations of the pressure test.

TISSUE CHARACTERISTICS

As apples mature and ripen starch and astringent constituents decrease. Tests for starch with an iodine and potassium iodide solution have proved unreliable because of the variability in starch among individual fruits of practically the same degree of maturity and because of variability due to heavy and light crops and seasonal growing conditions. Familiarity with the astringent taste of apple tissue is a guide to picking maturity of varieties like Delicious and its red bud sports; satisfactory maturity is not acquired until sensations from astringency are practically absent. This is usually associated with loss of toughness in tissue texture. Water core in the tissue is a very important consideration in determining when to pick certain varieties. Investigations by Brooks and Fisher (*4*) show that water core develops first in fruit exposed to direct sunshine on the south and west sides of trees. Consequently, apples from these parts and the tops of trees should be examined for water core. As maturity advances water core increases; this generally is a signal that the fruit is passing the optimum state of picking maturity and may become subject to internal breakdown early in storage.

GENERAL RECOMMENDATIONS FOR PICKING

Because no single criterion is entirely dependable for determining when to pick, the grower usually must base his decision on a number of factors. A tentative date on which to start picking a variety should be established on the basis of the number of days from full bloom. As this date approaches the fruit should be watched closely. If the fruit shows signs of advanced maturity, such as a break in the ground color, a tendency of sound fruit to drop, water core, and loss of astringency and bitterness, the picking date should be advanced. On the other hand, if the apples are still green in color, hard, tough or woody in texture, and astringent or bitter in taste, it may be advisable to delay picking beyond the tentative date. The date of picking will probably need to be advanced with a light crop or exceptionally warm weather after bloom; conversely, a heavy crop or cold weather after bloom is likely to delay the date of picking.

WHEN TO PACK APPLES

Ideally, apples should be packed and stored or shipped immediately after being picked. Danger of blue mold infection is less if this can be done because injury to the apples during the packing operations is much less likely if the fruit is hard than if it has begun to soften. Scald

can also be controlled much more effectively if oiled paper is applied soon after the apples are harvested. Unless the oiled paper is applied within a month, or 6 weeks at the most, it is ineffective in controlling scald. Another advantage of prompt packing is that it gives an opportunity to sort out the culls, which not only may be sources of infection by rot organisms but which also take up storage space that may be needed for marketable fruit.

Practically, however, a large part of the crop is often kept from a few days to several months before it is packed for market. Sometimes this delay is due to lack of packing facilities that will take care of the fruit as fast as it is picked, and sometimes packing is intentionally postponed or spread out. If the apples are particularly susceptible to bitter pit, it may be advisable to delay packing for a month or 6 weeks to give the disease a chance to become manifest so that affected apples can be sorted out. When the delay is for more than a few days, the fruit is ordinarily placed in storage and packed at the convenience of the owner. Although this has some advantages, especially from the standpoint of spreading labor, these are outweighed by the disadvantages. When packing houses are congested and cold-storage space is not available, it is ordinarily preferable to leave the picked fruit in the orchard in the shade of the trees; the boxes should be spaced so that air can circulate freely about them, and the stacks should be covered so as to protect the fruit from direct sunlight and rain (fig. 2). The apples will ripen less rapidly than if stacked in the open in unprotected large piles at the packing house, as is sometimes done (fig. 3).

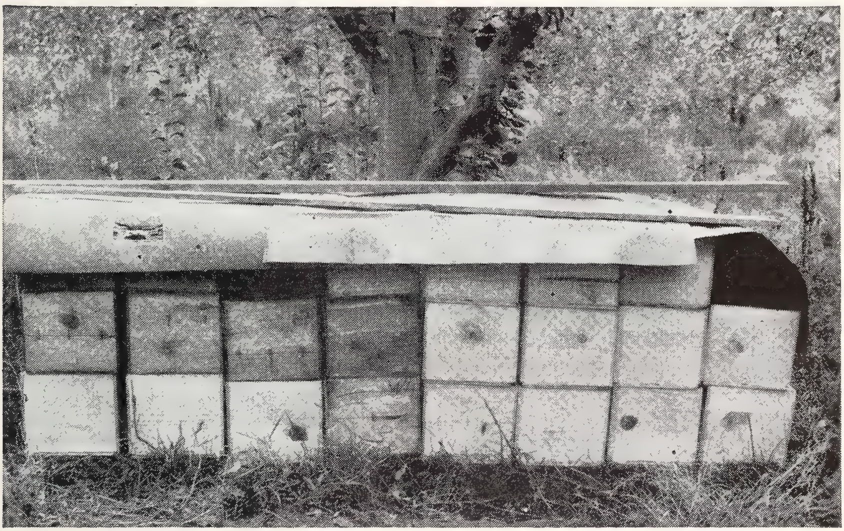

FIGURE 2.—Boxes of apples in the shade of a tree in an orchard. The boxes are covered to protect the fruit from direct sunlight and rain, yet the air can circulate freely about them.

FIGURE 3.—Holding apples in large compact stacks outside a packing house is not recommended. In such piles, unprotected from sunlight and rain, ripening is accelerated.

FACTORS AFFECTING CONDITION DURING STORAGE

The sequence of changes in the harvested fruit is much the same as in apples that are allowed to remain on the tree until they become overripe, mealy, and insipid; that is, even fruit harvested at the proper stage of maturity eventually becomes mealy and flavorless if held too long or under improper storage conditions. In fact, unless the fruit is placed in cold storage promptly, the approach of senility is more rapid after the fruit is picked than when it is left on the tree. The length of time that apples can be held in satisfactory condition in storage depends on three factors: (1) Maturity at harvest; (2) storage temperature; and (3) presence of diseases.

MATURITY AT HARVEST

Apples picked before they are sufficiently mature generally remain sour and astringent, even after they have ripened, and, except for the red bud sports, are poorly colored. They have a marked tendency to wilt or shrivel and are susceptible to scald and bitter pit during storage.

The apples most often picked before they reach the proper stage of maturity are the solid-color varieties, such as Grimes Golden and Yellow Newtown among the green or yellow kinds and the red bud sports of the Delicious. When picked at the proper stage of maturity, all these rate among the best for dessert quality; but when picked too soon, they are suitable only for cooking, and the Delicious is not particularly good even for that.

When the weather remains warm at harvesttime, particularly at night, some varieties of red apples are slow to color and there is a tendency on the part of growers to delay picking until the apples do color, with attendant danger of loss from dropping and of the fruit's becoming too mature for storage. Because this is particularly true of Jonathan, Delicious,

and Rome Beauty, red bud sports of these varieties have been eagerly sought and largely substituted wherever possible. Many large plantings of the original varieties will doubtless remain in heavy production, however, and will continue to pose problems of color, dropping, and overmaturity. Use of hormone sprays, which prevent dropping of the fruit, meets the problem of slow coloring only in part, because of the danger that apples thus held on the tree to color may become too far advanced in maturity or may be fully ripe at time of picking. An early picking of the fruit of advanced maturity so that it does not become overmature would then be desirable. Careful sorting during packing may also be desirable in order to remove fruit of advanced maturity, thus maintaining the storage quality of the pack. Overmature apples are particularly susceptible to water core, soft scald, internal breakdown, and Jonathan spot and are more subject to stem punctures, bruising, and other mechanical injuries through which blue mold infection takes place. Blue mold entering through lenticels is also more likely to infect overmature apples than those picked at proper maturity.

Storage Temperature

The life processes of apples that have to be considered in the successful storage of the fruit after harvest are essentially chemical, and, as with other chemical processes, the rate at which they proceed depends largely upon the temperature at which they can be carried out, that is, upon the temperature of the apples. Apples freeze at about 28.5° F. (*27*); hence, it is necessary to keep them above this temperature. In practice, storage temperatures of 30° to 32° have been found most satisfactory (*22*).

Magness and others (*16*) found that the rate of respiration largely governs the rate of ripening and softening of apples in storage. They found that at 40° F. this rate is approximately twice as rapid as at 32°; at 50° it is almost double that at 40°; and at 70° it is about twice as fast as at 50°. At 30°, on the other hand, 25 percent more time is required for apples to ripen than at 32°. These results emphasize the importance of quickly cooling apples to the minimum safe temperature for storage; the apples will ripen as much in 1 day at 70° as they will in 10 days at 30°. Holding apples at 70° for only 3 days after harvest thus will cut off about a month of their potential storage life at 30°. If 30° storage is not immediately available, every opportunity should be taken to cool the fruit, such as stacking it in the shade and providing good ventilation, especially at night (fig. 2). The same principle applies after storage. It is therefore inadvisable to remove from cold storage at one time more apples than can be used or marketed before they deteriorate seriously. It must also be remembered that after storage the span of life remaining for the fruit is much shortened, and, as the end point is uncertain, the gamble in holding at warm temperatures is much greater.

Cooling the fruit means the transfer of heat from the fruit to the surrounding air. The effectiveness of the cooling depends on the difference between the temperature of the air and that of the fruit and the rate at which the air moves over the fruit. In common storage, cooling is accomplished by transferring heat from the fruit to the outside air. A good ventilating system intelligently operated is necessary to make this method efficient; the vents should be opened when the outside air temperature is lower than that of the fruit and closed when conditions

are reversed. In cold storage the heat is transferred from the air surrounding the fruit to refrigerated pipes or other artificially cooled surfaces and eventually is transferred to the outside air by the refrigeration system (*11*).

Cooling fruit ordinarily is not a rapid process, nor is ripening checked instantaneously when fruit is placed in cold storage. Time is needed to remove the heat from the fruit; the rate of cooling is affected not only by the temperature but also by the type of package, the method of packing, the quantity of warm fruit placed in the room, the manner in which the packages are stacked, and the rate of air circulation around the fruit. Tests were conducted at the cold-storage laboratory of the Bureau of Plant Industry, Soils, and Agricultural Engineering, Beltsville, Md., to determine the influence of the type of package on the rate of cooling. The temperature records were taken at the core of an apple at the center of each package. The packages were not stacked and, being freely exposed on all sides, cooled faster than they would under commercial storage.

The results (table 1) show that the use of liners, cushions, and paper for packing slows the rate of cooling. Apples in an open bushel basket just as they came from the orchard, without liners, wraps, or shredded oiled paper, cooled from 63° to 32° F. in 18 hours, whereas fruit packed in lined baskets with a pad under the lid and shredded oiled paper well distributed throughout required about 10 days to cool from 70° to 32.5°. The relative thickness of the containers doubtless had an effect on the rate of cooling, but the size of the package, or the mass of fruit enclosed, and the tightness of closure apparently were important factors also, as shown by a comparison of the results for apples packed in the barrel with those for apples in the open bushel basket. It took only 18 hours to cool the fruit in the middle of the bushel basket from 63° to 32°, but it took 10 days to cool that in the middle of the 3-bushel barrel from 66° to 36°. Similar results were obtained with the apples packed in the standard box and in the 1⅕-bushel eastern crate; the packing in both

TABLE 1.—*Influence of method of packing and storing apples in unstacked individual packages on their rate of cooling at 32° F. in still air*

Package	Packing material	Temperature at core of apple in center of package—					
		When stored	After 12 hours	After 18 hours	After 72 hours	After 7 days	After 10 days
		°F.	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*
Bushel basket	None	63	42	32			
Do	Liner, cushion, shredded oiled paper.	70	59	44.5	41	33.5	32.5
Barrel	None	66	64	59	55	41	36
Standard box	Liner, cushion, oiled wraps.	71	67	60	54	41.5	37
1⅕-bushel eastern crate.	Liner, cushion, shredded oiled paper.	66	63	61	59	54	44

of these containers, however, included liners and pads, as well as oiled wraps or shredded oiled paper. The eastern crate contained 20 percent more apples and was the tighter package; after 10 days the fruit in its center had cooled only 22°, while that in the standard box had cooled 34°.

The results of the tests should not be interpreted to mean that use of pads, liners, and other packing material is undesirable, but rather that these materials insulate the fruit and increase the requirement for refrigeration if properly packed apples are to be cooled as quickly as is desirable.

In precooling apples, air at a temperature below 32° F. is used to rapidly lower the temperature of the fruit. The greater the difference between the temperature of the apples and that of the air, and the more rapid the rate of air movement, the more rapid the rate of cooling will be. However, as the temperature of the fruit approaches that of the cooling medium the rate drops (fig. 4).

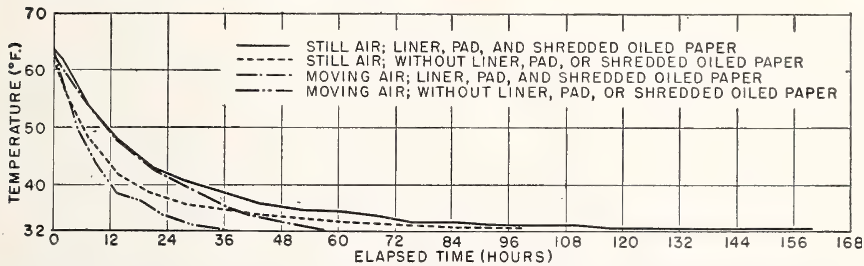

FIGURE 4.—Rates of cooling of apples packed in bushel baskets and stored at 32° F. in still and in moving air. Velocity of the moving air was approximately 200 feet per minute. The thermometer was placed in centermost fruit in each container.

Some persons believe that when apples are cooled too rapidly the quick change in temperature may produce shock to the fruit, with consequent ill effects. Only varieties that are susceptible to soft scald are likely to be injured by fast cooling in storage. With other varieties the more rapidly fruit can be cooled to the proper storage temperature, the more quickly will deteriorating processes of ripening be arrested and the longer the fruit can be kept in good condition.

While apples are not commercially precooled to the same extent as are peaches, pears, plums, and certain other fruits, in many cases it would undoubtedly be beneficial to precool them, Delicious in particular because this variety is so prone to become mealy and overripe. Records of fruit temperatures, if taken in many storages, would disclose that most of the fruit is not cooled to 32° for several weeks after harvest. Meanwhile, the rate of ripening is being arrested only in proportion to the rate of cooling. The slow cooling is often due to lack of sufficient refrigerating capacity of the cold-storage plant, but it may also be due to faulty stowage in the room, particularly failure to leave space for air circulation through the stacks and to spread out large receipts of warm fruit.

Records taken in packages held at 32° F. and stowed as they would be in commercial practice showed that the rate of cooling was faster in the top layers of the stacks because the air could circulate more freely there. The apples cooled more in the first 12 hours than in the next 12 and the rate of cooling fell off progressively thereafter as the temperature

of the fruit approached that of the air in the storage room. The insulating effect of the liners, pads, and shredded oiled paper ordinarily used is brought out in these results as well as in those in table 1. The effect of air movement in increasing the rate of cooling is also brought out clearly. When the rate of air movement was about 200 feet per minute, the apples without packing material cooled to 32° in 36 hours, while in still air they required more than 96 hours to reach this temperature. In the baskets with liners, pads, and shredded oiled paper similarly packed apples required 57 hours in the air moving at 200 feet a minute and more than 156 hours in still air.

In stacking packages in storage, adequate provision for the cold air to reach all packages in the room is essential, not only for the rapid removal of field heat but also for the continuous removal of the heat of respiration, thereby preventing the accumulation of heat and development of warm pockets in the storage room. This is not so serious a problem when apples are packed in bushel baskets (fig. 5) as when they are packed in crates, boxes, and cartons. Crates, boxes, and cartons should be spaced with from 2 to 3 inches between rows of stacks, and the rows should run in the direction of the air currents across the room. It is especially important to provide spacing when tight, close-fitting packages like cartons are stored; lath or other dunnage strips should be used to separate the packages in each stack.

FIGURE 5.—Method of stacking bushel baskets of apples and staggering them by placing each basket on the edges of those beneath to keep pressure away from centers of lids. Stacking baskets this way, instead of putting alternate baskets upside down as is sometimes done, permits better air circulation. Workmen should never stand or walk on the baskets.

Gas Storage

In England, some varieties of apples, particularly the leading cooking variety, Bramley's Seedling, in ordinary cold storage develop low-temperature breakdown. The same is true to a limited extent in certain parts of the United States, particularly with Yellow Newtown apples in the Pajaro Valley, Calif., and with McIntosh in New York State, in which brown core may develop excessively during storage at 32° F. The gas-storage method was developed by Kidd and West (*12*) in England to meet this problem. The method calls for an airtight storage chamber, in which the carbon dioxide produced in the respiration of the apples is allowed to build up to the desired concentration while the oxygen content of the storage air is reduced. The temperature of the storage room is usually held at 40°; so refrigeration is required in addition to the gas treatment. Because varieties differ in their response to different ratios of carbon dioxide to oxygen, separate chambers may be required for different varieties. The desired ratio is obtained either by pumping the storage air through a lye solution to absorb the excess carbon dioxide or by ventilating the chamber periodically to admit fresh air and build up the oxygen. As the vast bulk of the American apple crop can be held satisfactorily in cold storage and most varieties are not benefited by the gas treatment, it is not likely that this method of storage will have wide application in this country because of the added cost and extra work that it entails. However, for special situations it may be utilized profitably despite the extra cost. Several gas storage rooms have been put into operation in New York for the storage of McIntosh apples in accordance with the recommendations of Smock and Van Doren (*26*).

Atmospheric Humidity

Keeping the apples from wilting and shriveling is as important as keeping them from getting overripe. It can be done by controlling the humidity in the storage space. A certain amount of moisture is continuously lost by the apples through the process of transpiration (evaporation).

Although evaporation can be cut down by reducing the temperature, it is particularly serious in apples which are not properly matured and on which lenticels are not normally corked over and the wax coating is not sufficiently developed. The natural barrier to loss through evaporation is the waxy skin of the fruit. Any injury to the skin or the removal of the wax, as in some washing processes, facilitates moisture loss and increases the severity of wilting. Careful handling to avoid bruising and injury of the skin and the use of proper washing processes are important therefore in preventing excessive wilting or shrinkage in storage, as well as blue mold rot and other types of decay. The drier the air the greater is the degree of wilting. If the relative humidity of the storage is maintained at 85 percent or higher, which is the approximate water content of apples, the pull on the fruit for moisture, or the evaporating power of the air, will be slight and shrinkage of the fruit will be correspondingly lessened. Where the relative humidity of the storage air is below optimum, the faster the air is moved over apples the more moisture will be

removed from the fruit; therefore, it is especially important to maintain an optimum relative humidity in cold storages with air-circulating systems, especially when fruit is stored in orchard crates or boxes. Observations in commercial cold-storage plants have shown that the relative humidity in the apple-storage rooms is frequently less than 85 percent, sometimes as low as 70 percent.

To maintain desirable humidity conditions so as to reduce wilting, it is well to fill the storage rooms, thus reducing as much as possible the ratio of air to fruit.

In designing a cold-storage plant it must be remembered that most of the moisture producing frost on the coils or diluting the brine used in a brine-spray chamber during the storage period comes from the fruit. The greater the temperature difference between the air and the cooling medium, whether it be coil surface or brine spray, the more rapid the condensation of moisture and the greater the drying effect on the atmosphere, thus increasing the pull on the fruit and causing wilting. Use of a brine spray in an air-circulating system is no insurance against low relative humidity; it will have the reverse effect if the temperature of the brine is greatly below that of the air. Consequently, it is essential that there be enough coil capacity, or enough coil capacity plus volume of brine spray, to provide the desired refrigeration without the cooling medium being more than 7° or 8° F. below the air temperature of the room (*11*). The adequacy of the building's insulation may play an important part in preventing shrivel in fruit, because the better the insulation the less difference there will be between the temperature of the air and that of the cooling medium.

It is difficult to raise the humidity in a cold-storage room kept within the most desirable temperature range for apples, 30° to 32° F., because the moisture is so quickly condensed and frozen. However, if it becomes necessary to raise the humidity, it can be done best by using a humidifying apparatus that introduces steam into the air of the storage room. A simple humidifier of this type can be made by placing a shallow pan of water on some strip heaters, operation of which is controlled through a humidistat. An electric fan should be arranged to blow over the surface of the water. The efficiency of the apparatus can be increased somewhat if absorbent toweling is looped into the water from a series of parallel supports placed 8 to 10 inches above the surface of the water. In this arrangement the air current from the fan should pass through the loops of the wicking. Adding moisture to raise the humidity by any method is only an expedient, not the most satisfactory method of controlling wilting and shrinkage. All that can be accomplished by evaporating moisture into the storage air is to meet some of the moisture requirement of the air rather than to permit it all to be taken from the apples. The moisture requirement of the air cannot be satisfied so long as the temperature of the cooling surfaces remains markedly below that of the air.

Other measures used to some extent to avoid the wilting effects of dry atmospheres are the coating of apples with wax or packing them in packages having moistureproof liners. These expedients have to be used with a degree of caution, as there is danger of sealing the apples too well. in which case the oxygen within the fruit is reduced to a point where the fruit cannot respire normally; this results in development of undesirable

flavors, sometimes in tissue breakdown. In apple waxing care must be taken to see that the wax used, or the thickness of its application, will not greatly interfere with normal respiration. If the apples are packed in consumer units of Pliofilm or similar transparent film, provision for gas exchange is necessary. If the package is sealed by heat or stapling, perforation of the film is essential to allow sufficient oxygen to reach the fruit. Such perforations are not necessary if incomplete closures, such as the "snap sack," are used. Such openings do not seriously reduce the effectiveness of the film in protecting the fruit against moisture loss.

Storage With Other Products

Apples absorb odors very readily; it is therefore undesirable to store them with other products that have pronounced odors. This is particularly true of potatoes and other root crops, which often give apples an earthy flavor. As apples give off ethylene, a gas that stimulates respiration and ripening, the potential keeping quality of other products stored with apples may be adversely affected. This is particularly true of cut flowers, which may be made to shed their petals or are otherwise injured by ethylene (*28*).

Air Purification

Recirculation of storage air through activated coconut shell charcoal has been suggested as a means of removing odors and the products of fruit respiration from the atmosphere in apple storages (*25*). This is an effective means of adsorbing odors until the adsorptive capacity of the charcoal filters is reached, whereupon it is necessary to replace the charcoal with a fresh charge. It has been found (*6*) that, although this material removes odors, it is relatively ineffective in removing ethylene, a product given off by ripening apples that stimulates the ripening processes in fruits. Air purification with activated charcoal removes volatile products other than ethylene sufficiently to reduce the intensity of apple scald, but it does not prevent scald as effectively as oiled paper. Ozone in apple storage removes odors and controls surface molds on packages and walls, but does not reduce decay or control scald (*22a*).

Fungus Diseases

Many fungus diseases of apples can cause serious losses under certain conditions. Fortunately, however, most of them are primarily orchard diseases and are controlled on the harvested fruit by the sprays that growers apply to control them in the orchard. However, if they are present on the stored fruit, they respond to storage temperatures about the same as do the physiological processes of the fruit (p. 9). All develop rapidly and are most destructive at higher temperatures; at 30° to 32° F. many will not develop at all, or at the most very slowly, particularly if the apples are not ripe. The spores of most rot organisms will not germinate at 30° to 32°, but if infection is already present when apples reach this temperature, most of the rots will persist during storage and the causal organism will resume growth after the fruit is removed to a warm place. Detailed information on the diseases of apples in storage is given in other publications of the United States Department

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of Agriculture (*3*, *20*). Discussion here is limited to a relatively few diseases that are especially influenced by harvesting, handling, and storage operations; most of them are not due to fungi but are functional or physiological in nature.

The storage disease responsible for most of the decay in apples after harvest is blue mold rot, caused by the fungus *Penicillium expansum* Link. It is primarily a wound parasite and ordinarily some kind of mechanical injury must be present before the fungus can infect an apple. This rot is very soft and watery and has a pronounced musty odor. It gets its name from the bluish masses of spores that appear on the surface of affected areas (fig. 6, *A*). This fungus is omnipresent wherever apples are grown, and its spores are found in large numbers on the surfaces of apples as they are picked and brought in for packing. As the fungus is ordinarily incapable of penetrating the sound, uninjured skin of the apple, careful handling of the fruit at all times is a prime requisite in

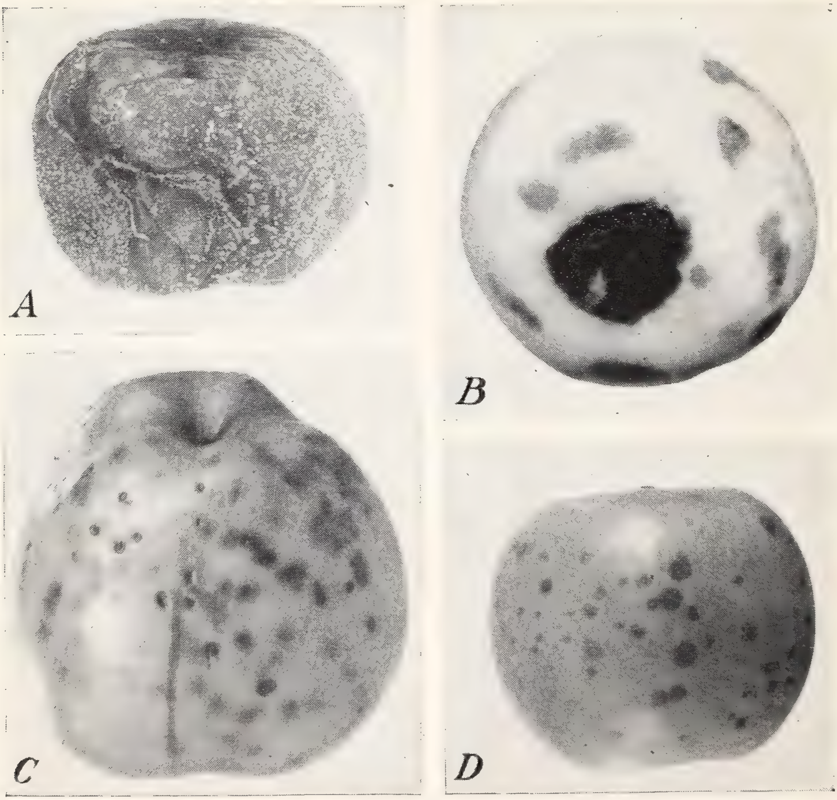

FIGURE 6.—*A*, Blue mold rot, which is soft and watery, has a pronounced musty odor and frequently is covered with bluish masses or spores. *B*, Very slight bruises, which show prominently on a peeled apple, emphasize need for careful handling at all times to keep the apples from being bruised. *C*, Bitter pit, which appears as brownish spongy or corky spots or pits in the flesh just under the skin and usually is most prevalent on the blossom end. *D*, Jonathan spot, a superficial skin disease that gives the apple a freckled appearance.

preventing infection. Bruising and other mechanical injuries lead to blue mold infection.

Although blue mold enters apples most often through mechanical injuries, it sometimes enters through open lenticels in the skin; through the stem, especially when this is enlarged or fleshy and has been broken or injured; and also through dead calyx lobes resulting from spray injury, washing injury, or other causes. Infection is more likely to occur in ripe apples than in those that are still hard; also it is most likely to occur at points of contact with other apples. When apples are washed the spores of decay organisms, especially blue mold, accumulate in the washing solutions and infection through both mechanical injuries and open lenticels is increased. The spore load of the washing solution should be kept as low as possible by sorting out rotten apples before washing, by careful handling to avoid injuries, by periodic renewal of the washing solution, and, where possible, by the use of a copious fresh water rinse. English (*5*) found sodium chlororthophenylphenate could be used effectively in washing tanks to kill the spores of blue and gray molds and greatly reduce rots caused by these organisms. This chemical is used extensively in the Pacific Northwest in washing apples and pears, and suggestions for its use have been published by the Oregon Agricultural Experiment Station (*13*).

In cutting down the loss from blue mold rot good sanitation in and around the packing house and storage rooms is important. As culls are potential sources of infection for other fruit, they should be stacked outside the packing house and disposed of to byproduct plants or otherwise at frequent intervals (fig. 7). Storage rooms should be kept clean and sanitary at all times, and before each season's use, they should be whitewashed, well disinfected, or otherwise thoroughly cleaned and aired. Whitewashing is simpler and generally preferable to other measures that can be taken. Adding copper sulfate increases somewhat the

FIGURE 7.—Hauling cull apples from the packing house. Frequent disposal of culls reduces sources of infection by decay fungi.

disinfectant properties of whitewash, but from a practical standpoint this is of questionable value. It is especially desirable, however, to clean and disinfect the floor, which is not whitewashed. Thorough scrubbing with water containing about 0.5 percent sodium hypochlorite and a suitable wetting agent is recommended. A number of commercial preparations on the market are suitable for the purpose.

For disinfection, sulfur dioxide, the gas produced by burning sulfur, can be used. The proportion ordinarily used is 1 pound of sulfur to 1,000 cubic feet of space. It should be burned in a metal vessel placed on bricks or otherwise held off the floor. All openings should be kept tightly closed for an hour or so in order to permit utilization of the maximum concentration of sulfur dioxide. Sulfur dioxide is most effective when floors are sprinkled to create a moist atmosphere; as this increases its corrosive effect on metals it is recommended that motors within the room be tightly wrapped with waterproof paper to prevent possible injury. Ordinarily formaldehyde candles can likewise be burned as in household disinfection, but formaldehyde is less satisfactory than sulfur dioxide because of the persistence of the odor, and thorough airing out for a considerable period afterward is required.

***Caution*.—Both sulfur dioxide and formaldehyde are toxic and injurious to apples, and no fruit should be placed in the rooms until all traces of gas have disappeared. They are likewise strong irritants to eyes and mucous membranes. Care must be exercised to avoid contact with the fumes during or after fumigation. Doors or windows should be opened to air the rooms thoroughly after fumigation and before they are entered by workmen. It is feasible therefore to fumigate only during the season when the storage space is not in use.**

Bruising and Other Mechanical Injuries

The importance of bruising and other mechanical injuries in blue mold infection emphasizes the need for preventing such injuries. Pickers, sorters, and packers should wear gloves or trim their fingernails closely to prevent fingernail punctures. All sand, splinters, and projecting nails in the fruit boxes or baskets should be removed. Pickers should be provided with containers having rigid sides, rather than with picking bags (fig. 8), to prevent bruising the apples when the picker leans against the container, as he often does in picking from a ladder or in the tree. Pickers should empty the fruit carefully into the field boxes. They should never drop apples more than an inch or two. Field boxes should be filled less than level full, in order to prevent bruising the fruit when stacked (fig. 9), and care should be exercised in lidding the market packages to prevent cuts or bruises in the fruit. Use of adequate grading and sizing machinery, which moves the fruit gently on belts or rollers, is an important factor in the reduction of bruising damage (fig. 10). Bad bruising often results from lack of adequate precautions in handling the fruit in the packing house, particularly when the fruit is dumped into the washing or sizing machinery. If it is poured out of the field crates and allowed to drop or if it is poured or rolled around in large piles, it is likely to be bruised and stem-punctured. Unless the apple-handling machinery is properly adjusted bruising may also occur.

A certain amount of bruising during packing and handling probably is inevitable, but most of the serious damage can be eliminated by careful

FIGURE 8.—Buckets are preferable to picking bags, because they afford more protection against bruising and stem punctures. In emptying, the containers should be lowered to bottom of the field box so that the apples will slip out gently. The boxes should not be filled so full that they cannot be stacked without injuring the apples, as would happen with the improperly filled box shown here.

handling, which, in turn, can ordinarily be obtained only by adequate supervision and the use of proper equipment.

In a study of picking bruises made in Washington orchards (*24*) the number of punctures, bruises, and pulled stems was recorded periodically. It was shown that where an orchardist adequately supervised the work of his pickers, there were 37 bruises per 100 apples, of

FIGURE 9.—Field boxes properly filled and stacked to prevent damage to the fruit and to facilitate cooling on the receiving platform of a packing house.

which only 2 were severe; and where the work of pickers was not carefully supervised, there were 398 bruises per 100 apples, of which 14 were severe. One cooperative association employed a man full time to inspect samples of every load received; his reports on injuries found were promptly sent back to the orchard. As a result, the orchardist's attention was called to bad workmanship, and picking bruises became noticeably low. Examinations of picking bruises in several orchards where metal picking buckets with canvas bottoms were used showed (*23*) an average of 1 severe bruise per 100 fruits; whereas in orchards where canvas bags were used there was an average of 3.75.

The use of pallets and fork-lift trucks for hauling and handling apples before packing is being adopted in some growing sections to save time and labor in receiving, stacking, and handling at the packing house. Studies conducted in Washington orchards (*23*) show that the more gentle and fewer handlings resulting from use of this method produce substantially fewer bruises (table 2). In these studies a severe bruise was considered to be a marked blemish to the appearance of the fruit and was generally at least one-half inch in diameter. The slight bruises recorded would not be discriminated against on the market, but they show up rather prominently when an apple is peeled. Slight bruises are also a decay hazard when caused before the washing process; even a

FIGURE 10.—Use of adequate grading and sizing machinery, an important factor in the reduction of bruising. All the sorters should wear gloves.

slight bruise may disorganize the cell structure at the base of lenticels sufficiently to provide a microscopic opening for entrance of decay organisms during washing and packing. Skin-punctured apples are generally regarded as culls, because it is well known that they are likely

TABLE 2.—*Comparison of injuries incurred by two methods of handling unpacked apples* [1]

Handling method	Fruits checked	Injuries caused per 100 fruits			
		Skin punctures	Bruises		
			Severe	Slight	Total
	Number	*Number*	*Number*	*Number*	*Number*
Hauling from orchard:					
By individual boxes	9,309	1.1	3.3	37.4	40.7
On pallets	9,278	.1	.9	6.8	7.7
Storing prior to packing:					
By individual boxes	3,972	0	8.8	43.4	52.2
On pallets [2]	3,152	0	5.9	26.3	32.2

[1] From 1948 studies with Delicious apples in Washington.
[2] Careless handling with fork-lift trucks.

to become infected with blue mold and in consequence are only suitable for immediate consumption. It is not so commonly recognized that apples with severe bruises should be culled out. Bad bruises not only detract from the sales appeal of the fruit but are also potential avenues of blue mold infection to almost the same extent as are skin punctures.

Physiological Diseases

BITTER PIT

Bitter pit, Baldwin spot, or stippin, as it is variously called, is a physiological disease found all over the world where apples are grown. It appears as brownish spongy or corky spots or pits in the flesh just under the skin and usually is most prevalent at the blossom end (fig. 6, *C*). Occasionally the pits are deep-seated and are not evident without cutting the apple. The affected part often has a somewhat bitter taste, which accounts for the name. Bitter pit does not impair the keeping quality of the apples, but, because the affected parts have to be pared away, it reduces the value of the fruit, and, of course, detracts from its appearance.

No variety is entirely immune, but bitter pit is particularly prevalent in Baldwin, Gravenstein, Arkansas (Mammoth Black Twig), Delicious, Yellow Newtown, Rhode Island Greening, and Northern Spy. The disease is most likely to occur in light-crop years, and apples grown on young trees are particularly susceptible. Susceptibility to the disease is also increased when late-season growth is stimulated by heavy irrigation or rains, fertilization, heavy pruning, or other means. Bitter pit may begin to appear before the apples are picked and seems to develop to the greatest extent if they are picked before they reach proper maturity, but as the disease is seldom fully manifested by the time of harvest it is impossible at that time to sort out all of the apples which will show the pitting. Ordinarily, however, the diseased apples can be detected within a month or 6 weeks after they are picked, and if susceptible crops are held until then before sorting and packing the pitted fruit can be eliminated. If this procedure were more generally followed, there would be less likelihood of having to repack affected lots or suffer heavy market losses because of bitter pit.

JONATHAN SPOT

Jonathan spot is a superficial skin disease characterized by small black or brown spots resembling freckles scattered over the apple, particularly on the well-colored part (fig. 6, *D*). In later stages these spots may become sunken and the flesh immediately beneath becomes brown and spongy as the tissue dries out. The disease affects the appearance and sales value of the fruit rather than its keeping quality. Jonathans are very susceptible, but the disease occurs also on many other varieties. The same kind of spot or one closely resembling it often seriously detracts from the appearance of Rome Beauty apples. Jonathan spot is only skin deep except in late stages, when underlying flesh tissue becomes brown and dried.

Jonathan spot is a physiological or functional trouble. It occurs to some extent on highly colored apples left on the tree until they become overripe, but primarily it is a storage disease that is most serious on apples held in warm places. Ordinarily its presence is an indication that the apples are ripe or well advanced toward full ripeness and that their further storage life is not long. It can be prevented almost entirely by picking the apples at the proper stage of maturity and storing them promptly at a temperature of 30° to 32° F. The greater the delay in reaching cold storage the more serious the disease. Storage at temperatures higher than 30° to 32° tends to increase the severity of the disease.

WATER CORE

Water core is a functional disease that appears in the apples before harvest and gives the flesh a water-soaked, or glassy, appearance, re-

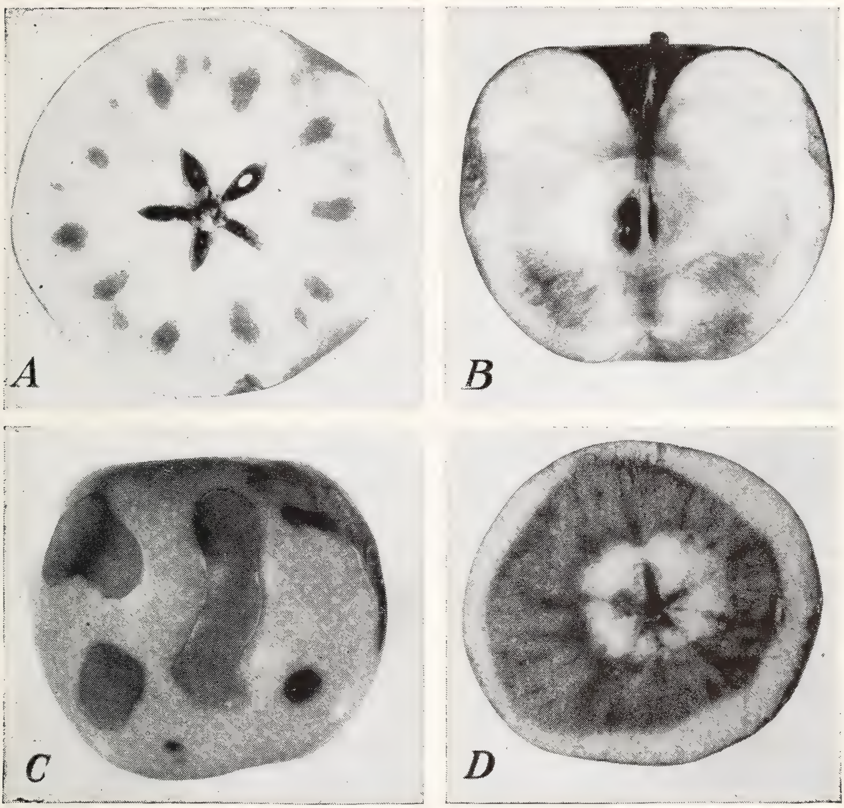

FIGURE 11.—*A*, Water core, characterized by a glassy, or water-soaked, appearance of the flesh around the core or main vascular bundles. Such affected apples are predisposed to internal breakdown. *B*, Internal breakdown, characterized by a general mealiness and brownish discoloration of the flesh. *C*, Soft scald, which makes apples look as if they might have been rolled on a hot stove. *D*, Soggy breakdown, which is brought about by causes similar to those which produce soft scald.

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sulting from the gorging of the tissues and intercellular spaces with sap (fig. 11, *A*). Because it usually becomes worse as the apples reach maturity, its appearance sometimes causes growers to pick the fruit earlier than would otherwise be desirable. It is usually most severe on the highly colored and most exposed apples in the tops of the trees; the poorly colored, shaded fruit may be entirely free.

When water core extends to the skin of the apple it is easily detectable and such fruit is seldom packed. However, it is often hard to detect slight water core, especially if it does not extend to the skin. Consequently affected apples sometimes are stored unintentionally. Growers who are not aware of the hazard likewise may store water-cored crops.

As water core predisposes apples to internal breakdown (fig. 11, *B*), storing affected fruit for late marketing is always hazardous. Slight water core in the long-season, hard-textured varieties, Winesap and Yellow Newtown particularly, may disappear in storage without leaving any trace; but in the short-season, softer varieties, even slight water core is usually followed by internal breakdown, and this almost always happens with more severe water core in even the harder varieties.

INTERNAL BREAKDOWN

Internal breakdown is a senility disorder that marks the end of the storage life of apples. It is characterized by brownish discoloration of the flesh, development of mealiness, and loss of flavor. In advanced stages the skin of the apple cracks as though from internal pressure and one can easily press the thumb deep into the flesh. In earlier stages, however, there may be no outward symptoms except possibly a dull color of the skin, often confined to the affected area. Cutting the apple, however, reveals a brown discoloration in the flesh (fig. 11, *B*), sometimes only in the core region, sometimes throughout the whole interior, and sometimes localized on only one side of the fruit. Occasionally, the breakdown will be found at severe bruises. In such cases it doubtless is due to the localized stimulation of respiration, which follows the injury. This is another reason for careful handling to avoid bad bruises and for sorting out badly bruised apples.

As internal breakdown is a senility disease, its presence in a storage lot can ordinarily be taken as an indication that the apples either were overmature when picked or have become overripe in storage. Further holding of such lots is hazardous. The best way to prevent internal breakdown is to harvest the fruit at the proper stage of maturity and to retard its life processes as much as possible thereafter by holding it at a temperature of 30° to 32° F.

SOFT SCALD AND SOGGY BREAKDOWN

Some varieties of apples are particularly subject to soft scald or soggy breakdown in cold storage. These diseases are very much alike in nature and cause, but they differ in their manifestation.

Apples affected by soft scald look as if they might have been rolled on a hot stove (fig. 11, *C*). Strips or large spots of the outer tissues are affected; the skin is dead and brown but tightly stretched with a very definite demarcation of the margin. The underlying flesh is brown and discolored. Only in late stages, however, is it more or less dried out;

earlier, it is soft and juicy. Frequently, rot fungi invade the fruit through the dead skin. They make black or brown spots of decay and soon destroy what is left of the apple. Blue mold and *Alternaria* are the most common invaders of soft-scald tissue. Jonathan, Rome Beauty, and McIntosh are the varieties most often affected with soft scald, but other varieties are sometimes affected also.

Much experimental work has been done on this disease, but very little has been discovered to explain its nature and cause, except that it is a low-temperature disorder. As a result, no categorical statements can be made regarding its control. In general, its incidence appears to be reduced or prevented by early harvest and prompt cold storage at 30° to 32° F. Delay up to 10 days or 2 weeks in placing the fruit at 30° to 32° seems to increase the tendency to the disease, but after longer delays the susceptibility of the fruit decreases. Well-matured or overmatured fruit is more susceptible to soft scald and should not be stored at temperatures below 36°. The disease is erratic; it may be bad one year and absent the next.

Soggy breakdown is most serious in Grimes Golden and Golden Delicious and appears to be the manifestation in these varieties of the same disorder exhibited by soft scald in others. Soggy breakdown differs from soft scald chiefly in its location, being typically a disease of the flesh, whereas soft scald is confined to the skin and adjacent flesh. Soft scald has a sharply defined margin in the skin; in soggy breakdown there is a more extensive involvement of the flesh beneath, without the sharp margin between the sound and the affected tissues (fig. 11, *D*). It seems to be associated with the same storage conditions as soft scald.

SCALD

Scald occurs principally in storage; it is a rather generally diffused browning of the apple skin. At first it is superficial, but eventually the skin may become soft and it can be readily sloughed off. Then the flesh beneath either dries out or is opened to infection by rot fungi. The green, or unblushed, parts of the fruit are most affected, and immature apples are more susceptible than those picked later.

Scald can be understood best by thinking of it as a disease induced by suffocation or auto-intoxication; that is, it appears to be caused by products given off by the apple itself. The particular products involved apparently are connected with the odorous constituents of the apples.

Scald itself affects the appearance and not the dessert or cooking quality of the fruit. However, the presence of scald means that the further storage life of the fruit is limited because scalded skin is dead and offers no further protection to the fruit. The disease is likely to spread rapidly until almost all the surface, particularly the green-colored areas, is involved. It does not ordinarily begin to appear until 60 days or more after harvest and commonly is more serious on apples in cold storage than on those in common storage. Sometimes it does not become manifest until after the apples are removed to a warmer place. Usually it becomes more serious after such transfer, but this is a result of conditions that prevailed during cold storage.

In the prevention of scald, picking the fruit at proper maturity and selecting only the best-colored fruit for long-time storage are important, but in preventing loss from the disease further measures must be taken.

Since it is due to auto-intoxication effects in storage, storage practices must be adapted to prevent its occurrence. If it were practical to provide continuous aeration of every apple, the injurious odorous emanations could be removed in this way and scald control could be obtained, but it is not possible to do this in commercial packages or under commercial cold-storage practices. The only feasible method of scald control is the use of oiled paper (fig. 12) as developed by Brooks, Cooley, and Fisher (*2*). The oiled paper can be used either in the form of fruit wraps or shredded. It absorbs the odorous emanations from the fruit and at the same time reduces moisture loss from the fruit. Its use is recommended for all fall and winter varieties of apples. For best results the apples should be packed in the oiled paper as soon as possible after harvest. Oiled paper for this purpose is now obtainable in all apple-growing districts, but growers should make sure that it is properly prepared and properly used. It should carry at least 15 percent of its dry weight in an odorless and tasteless mineral oil. When shredded

FIGURE 12.—Control of scald on Grimes Golden apples by use of wraps carrying odorless, colorless mineral oil to at least 15 percent of their dry weight.

oiled paper is used, at least ½ pound per bushel is required, and it should be well distributed through the package so that every apple is in contact with it.

EFFECTS OF PACKAGING

Packaging practices have an important bearing on the subsequent condition of apples, especially as to bruising, and particularly when apples are displayed to the consumer. It is a strange commentary on the apple industry that after taking great care to cull out all skin-punctured and badly bruised fruit, many packers package their apples in such

a way as to bruise and puncture a large proportion of the good fruit remaining. Surveys in retail stores in various parts of the country reveal that the outstanding defect in the apples offered for sale is bruising—often very bad bruising. In self-service stores customers naturally do not select badly bruised apples and in other stores such apples are heavily discounted. Offering bruised fruit is contrary to the interests of both seller and buyer, as well as of the producer. Often the industry as a whole suffers in consequence, not only because of low profits but also because consumers turn to more attractive competing fruits—fresh, frozen, or canned—which may be available in the same store.

Examination of the apples before they are removed from the original container shows that much of the bad bruising occurs after the fruit is packed. The greatest single factor in producing this damage is the trade's insistence on a high bulge or heavy pack so that apples can be bought by the package and sold by the pound. A high-bulge pack usually brings the producer a few cents more than one that is merely tight (as distinct from a slack pack); so many growers make it a rule to put on the high bulge. Because such packs are favored in the wholesale trade but ultimately result in slowing down retail sales, their widespread use points to a notable lack of coordination among the various factors concerned in handling the commercial apple crop. However, for the reasons indicated, it is not likely that this situation can be corrected without an industry-wide effort. If the grower or packer could reach the consumer directly, the practice would be abolished very quickly, but when their contact is remote, and through intermediaries whose interest in apples is only incidental, the problem becomes very difficult.

Results of a survey conducted in the winter of 1940–41 by Crandall in the retail stores of Columbus, Ohio, and reported by Nold (*19*), show the extent to which bruising is found in apples offered for sale in retail stores, as follows:

In determining the various types of damage, the following classification was used: 1. *Slightly bruised*—(Enough damage to affect the external appearance); 2. *Severely bruised*—(Many small bruises or large bruises an inch or more in diameter); 3. *Undecayed skin breaks;* 4. *Decayed skin breaks.*

. . . the average grocer's display [of apples was found to contain the following:]

Sound fruit	57.9%
Slightly bruised	21.9
Severely bruised	11.4
Skin breaks, undecayed	5.2
Skin breaks, decayed	3.6

. . . Since almost all of the fruit examined came either from the West Coast or from Ohio, a check was made of the extent and type of damage prevalent on the fruit from these two regions.

	Ohio	*Western*
Slightly bruised	20.2	24.1
Severely bruised	8.0	15.3
Skin breaks	6.6	3.5
Decayed skin breaks	4.4	2.7
Sound	60.9	54.3

. . . The Western fruit showed a large percentage of bruises caused by high pressures . . . Some boxes of fruit came through with very few if any pressure bruises while others had as high as 50 percent severe bruising. Much of the damage is due to overpacking the boxes in an effort to secure a heavy pack . . .

The Ohio-grown apples showed severe bruises that were evidently caused, for the most part, by careless handling. Some of the severe bruising can be attributed to the packing methods and containers . . .

The practice of overpacking alone accounts for many of the bruises present on the apples in the grocers' displays. For every apple added to form an extra large bulge, there is at least one severely bruised apple and several slightly bruised ones. The extra weight added in the form of a large bulge is more than offset by the waste and falling-off in condition due to overpacking . . .

The type of package used has an important bearing on the prevalence and severity of bruising that occurs during the handling of packed fruit. The continuous-stave bushel basket is so generally recognized as unsuitable for fruit that it is not necessary to cite experimental results to prove the point. Nevertheless, this package is still used to some extent for apples. It is impossible to get and keep a firm, tight pack in this type of basket. The nonrigidity of any side of the package makes it give under pressure and permits the apples to be bruised or punctured in much the same way that they are when a bag is used as a picking container (p. 18). The nonrigidity of such baskets is especially objectionable when they are stacked in storage or in transit.

The export tub is far superior to the continuous-stave bushel basket. It has rigid sides and bottom, and the lid provides enough tension to keep the pack tight. Overfilling this package is likely to result in rim cuts as well as in bad bruising from pressure of the lid (fig. 13). Use of a liner around the sides and a cushion or pad under the lid, although retarding cooling as shown in table 1, is always desirable with bushel baskets, in order to reduce the hazard of puncturing the apples by sharp edges of the staves and the ends of the staples which sometimes project on the inside.

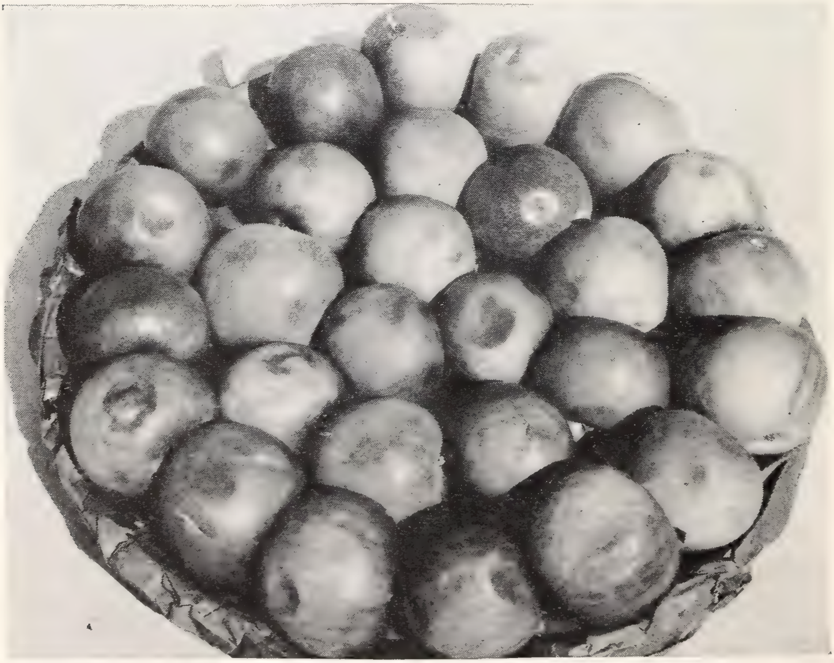

FIGURE 13.—Bruised and cut Stayman Winesap apples from the top layer of a tub-type bushel basket that was packed too tightly. All the apples except one, which are arranged to show injuries, were cut or badly bruised.

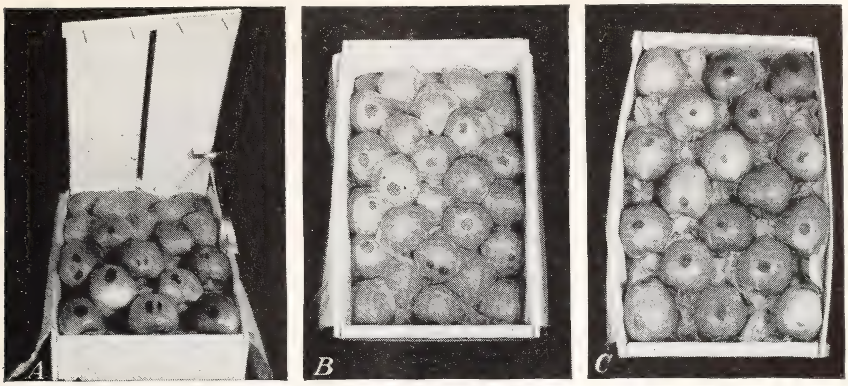

FIGURE 14.—Bruised apples from overfilled standard box, like those in figure 15: *A*, Severely bruised top layer, which could have been protected by a pad; *B*, second layer showing outlines of bad bruises caused by pressure of first layer that was increased by uneven sizing of the fruit; *C*, side layer showing bruises caused by stacking boxes on bulged sides.

Close sizing of the fruit and place packing, or regular alinement, of the fruit in the box are important in reducing the number of bruised apples in a pack (fig. 14). Western packs, as a rule, are superior to eastern packs, because the western packers use mechanical sizing machines, so that variations of more than one-fourth of an inch in the diameter of apples in a package are rare. Fruit of each size is packed according to a mathematical pattern. Also, each apple is wrapped separately, a protection against bruising. Eastern packers, on the other hand, often separate their apples into two sizes only—those larger and those smaller than a certain minimum, usually 2½, 2¾, or 3 inches in diameter. They may face their packages with apples of approximately the same size, but the jumble fill makes possible a good deal of bruising, because the apples are not definitely placed and also because of the uneven pressure of one apple against another that results when apples of different sizes are packed together.

Studies by the United States Department of Agriculture show the effect of packing on the bruising of the fruit (table 3). Apples from the

TABLE 3.—*Comparison of bruising of Stayman Winesap apples packed in standard apple box (northwestern box) and 1⅕-bushel eastern crate*

Package	Apples badly bruised—	
	Against each other	Against package
	Percent	*Percent*
Standard box	4	[1] 14
1⅕-bushel eastern crate	12	[2] 29

[1] The distribution of this bruising was as follows: Top and bottom layers (against padded lids), 1 percent; sides and ends (no pads but paper liners over sides), 13 percent.
[2] The distribution of this bruising was as follows: Top layer (against pad), 1 percent; bottom layer (no pad), 12 percent; sides and ends (cardboard liners but no pads), 16 percent.

same lot were packed at the same time in a Virginia orchard—part in a 1⅕-bushel apple crate and part in a standard apple box. Those in the standard box were sized to pack 100 to the box; those in the crate were sized 3 inches and larger, in accordance with commercial practice. Oiled paper was used to wrap the apples in the standard box; shredded oiled paper was used in the crate. Both packages had liners. Both also had pads under the lids, but only the standard box had a pad in the bottom. Both packs of apples were hauled by truck to Washington, D. C., where they were held in cold storage for several months and then examined. The results of the examination are given in table 3. The study revealed

FIGURE 15.—Bulging of top, bottom, and sides of standard boxes because of overfilling. When such overfilled boxes are put under pressure in a stack serious bruising results on apples in contact with the sides and the lids.

also that a pad on the bottom, as well as on the top, of the package helps to prevent bruising of the fruit.

FIGURE 16.—Rome Beauty apples, showing typical flattened bruises produced by jolting or vibration of the standard box against the car floor. Such injury can be largely prevented by a cushion liner and careful handling of boxes.

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Bad bruising of western apples is usually the result of poor sizing, poor alinement, overfilling (fig. 15) or rough handling of boxes, or of jolting in the bottom layers of boxes in the car during shipment. Apple boxes are loaded on their sides, and it is not uncommon to find all apples that are in contact with sides of boxes next to floor racks flattened (fig. 16). This type of injury, sometimes mistaken for freezing damage, can be lessened by use of a resilient cushion liner between the apples and the sides of the box (*21*). Unpublished data of the United States Department of Agriculture show that apples in boxes lined with 4-way pads, which received regular commercial handling between a northwestern cold storage and Texas retail stores, had 95.8 percent more severe bruises than those in boxes protected from forceful impacts during car loading and market distribution.

Sometimes apple boxes are overfilled to such an extent that they bulge on the sides, which are supposed to be rigid, as well as on the top and bottom (fig. 15). When a standard apple box rocks in a stack, the fruit is sure to be badly bruised before it reaches the market (fig. 14, *A* and *C*).

Of increasing importance in commercial apple packaging is the use of tray packs (fig. 17). The pressed-wood-pulp trays have cup-shaped depressions to hold apples of a given size in perfect alinement and are fitted in wood boxes or fiberboard cartons of slightly larger dimensions than a standard apple box. Packing may be done by unskilled packers if the apples are mechanically sized. These packages have proved very effective in preventing the large bruises incident to box closure and

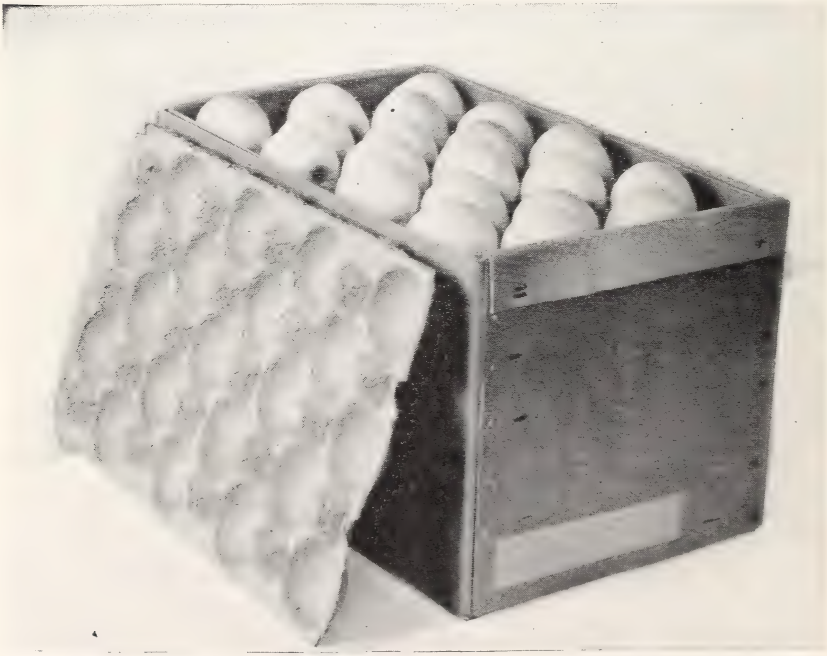

FIGURE 17.—Fiberboard carton used for a tray pack. The pressed-wood-pulp tray, shown at the side of the carton, holds a layer of apples and protects the fruit from excessive bruising against the sides and bottom of the container.

heavy impacts received during car loading, transit, and market distribution. The tray pack is growing in favor with buyers for self-service markets where heavy bruising constitutes a difficult display and merchandising problem.

Fiberboard boxes, though not in common use for packing apples, are being increasingly used for specialized packs. They may be used with the tray-packs described above, as shipping containers for various types of consumer packages, or with egg-crate-type cells for individual apples (fig. 18). The latter afford maximum protection against bruising. Because of the diversity of sizes of the egg-cell inserts required for different sizes of apples, boxes of various shapes and dimensions are required. This makes it difficult to stack them in cars, trucks, or storages economically. Corrugated fiberboard is a good insulating material; consequently allowance for ventilation should be made in their design. They hold the fruit less rigidly in place than wooden containers, and if they are not moistureproofed they tend to soften at the high humidities desirable for apple storage. However, shipments of apples in fiberboard boxes have been made from the Northwest to eastern markets in which the fruit arrived in as good condition as that in the standard boxes.

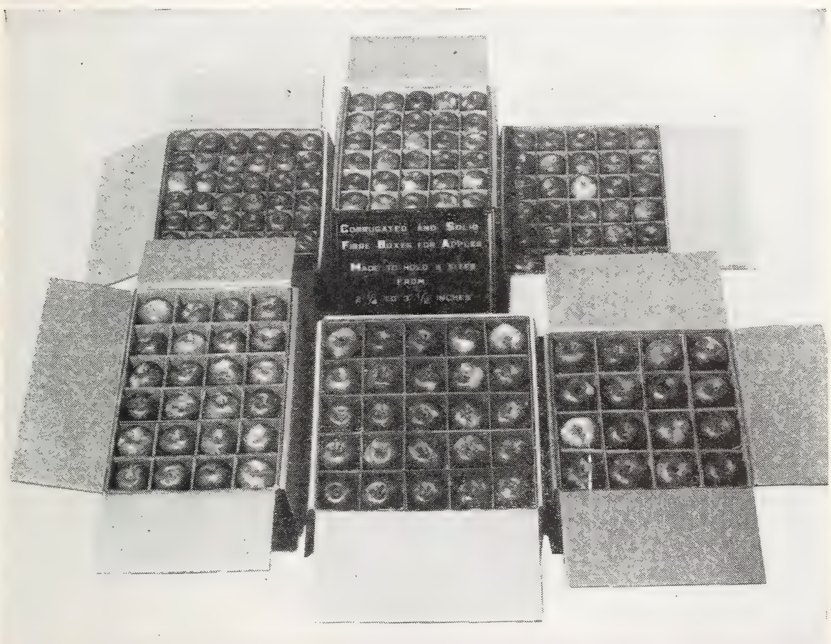

Figure 18.—Egg-crate type of fiberboard containers, which afford maximum protection against bruising. A disadvantage of this type is the diversity of shapes required for apples of different sizes.

Prepackaging for the Consumer

A wide variety of packages, varying in size from ½ bushel down to a 2-pound carton, have been used in an effort to find a container that

the retailer could offer for sale as a consumer unit. In addition to those mentioned, various paper boxes, overwrapped trays or boats, mesh bags, and bags made of transparent films have been used (figs. 19 and 20). As the smaller 2- to 5-pound units are usually shipped in master containers without excessive closure pressure, the apples so packed reach the retail store with fewer bruises than those packed and shipped in ordinary containers.

Apples to be prepackaged must be sound when packed and not subject to such disorders as rots, soft scald, bitter pit, breakdown, or scald during transit and market distribution. This is very demanding. Scald, for instance, may make it impossible to pack certain varieties within 2 months after harvest or necessitate packing them in oiled paper at the time of harvest. Apples become increasingly susceptible to rot invasions as the storage season progresses. Hence safeguards against decay invasions must continuously be intensified when prepackaging during the winter.

FIGURE 19.—A 5-pound carton of York Imperial apples packed for the consumer in a Virginia packing house.

The package must adequately display the apples or the consumer will select fruits from bulk displays. Net mesh bags may make an imprint on soft varieties. Film packages should be perforated, or at least not completely sealed, so that apples will not develop undesirable flavors because of lack of oxygen. Each package must contain more than the stated net weight when packed to allow for shrinkage during distribu-

FIGURE 20.—Apples packed for the consumer in bags made of transparent film.

tion. Otherwise, the retailer may become liable for violation of local weight and measure laws or ordinances. A closure that prevents removal of apples from one package to replace those in another is desirable for the package. Also, the consumer packages should be strong enough to resist breaking during delivery to the retail store and while being handled during display and sale by the retailer.

THE SHIPPER'S RESPONSIBILITY

Many apples are shipped to markets far from producing areas and frequently are in transit from 1 week to 2 or 3 weeks before being unloaded. Most of the shipments are made in refrigerator cars. The protective service they receive in transit depends on what is ordered by the shipper. It may be ventilation, refrigeration, or heater service for protection against freezing.

Because apples are not highly perishable, like peaches or strawberries for example, and move during the cool seasons, many shippers order their cars shipped under ventilation. Under this service no particular control of the temperature of the load is possible; the vents are kept open at all times when the outside temperature is above a stated minimum, usually 32° F., and are closed when the outside temperature drops to this minimum. If the fruit is warm when it is loaded, cooling in transit depends entirely on lower outside temperatures. If the fruit is colder than the outside air, the load will warm up. This is particularly likely with shipments from cold storage. Such shipments should never be forwarded under ventilation service. If transit refrigeration is not desired, they should be billed "Plugs in. Vents closed to destination." Thus the refrigeration stored up in the cold load can be utilized throughout the trip.

Movement under this service or under ventilation provides the cheapest services available to the shipper. From the standpoint of the condition of the fruit, the use of ventilation is justified only with apples that are intended for immediate use. With apples intended for storage at destination, ventilation service jeopardizes the potential storage life of the fruit because of the rapidity with which the ripening process proceeds at higher temperatures (p. 9). Consequently, as a rule, apples that move under ventilation are not worth as much as those that are refrigerated in transit. This does not mean that ventilated shipments necessarily sell for less than refrigerated consignments, but it does mean that they are likely to give less satisfaction to the consumer, thereby doubtless indirectly affecting the market for apples in general. Shippers who use ventilation service indiscriminately are to that extent increasing the hazards of the industry and inviting dissatisfaction among consumers, which must affect the demand for apples.

Shipments can be billed to move under standard refrigeration or various modifications of it. Under standard refrigeration the bunkers of the car are initially iced to capacity and are refilled at all regular icing stations en route (usually at least once every 24 hours), and the car is delivered with bunkers at least three-fourths full. When shipments are precooled or are loaded out of cold storage and move under standard refrigeration, maximum protection is obtained.

Sometimes modified refrigeration services can be utilized to effect savings in cost without sacrificing efficiency of refrigeration, and shippers are utilizing such services to an increasing extent. It is possible, however, that some apple shippers are going too far in this direction. The apple does not ripen as rapidly as some other fruits, but every day that it is kept above the optimum storage temperature means a progressive shortening of the time before it will become fully ripe and presently overripe and undesirable or unsalable. Consequently, protective services, providing relatively high temperatures during the transit period, interject an element of hidden damage to the potential storage quality of the fruit. The degree to which this damage may be hidden, or the time at which it will become apparent in the ripening of the fruit, depends on the condition of the apples at time of shipment and their temperature while in transit. It is more likely to be serious with varieties like Jonathan, Rome Beauty, and Delicious, which are often left on the trees until past proper picking stage in order to get more red color, than with later keeping varieties, such as Winesap and Yellow Newtown.

The effects of hidden damage are probably greatest in shipments that move under heater service. Mallison, Gorman, and Hukill (*18*) found that heater service often warms the fruit in the car to temperatures that would call for the use of refrigeration in summer shipments. Such inconsistency is due to the impossibility of closely regulating the heat supplied and its distribution in the car with ordinary heating devices. The temperature in the bottom of the load is sometimes down to freezing when that in the upper layers is up to 60° F. or higher. Unquestionably a great deal of damage has been done to winter shipments of Delicious and other varieties, which are especially prone to become mealy, by the heater service used to protect the fruit against freezing while in transit.

Recent investigations by the United States Department of Agriculture and the Association of American Railroads have shown that these conditions can be largely corrected by using heaters having thermostatically controlled burners in cars with air-circulating fans. The mechanical circulation of the air within the car was shown to be very important. It provided a means of protecting apples against freezing during short periods of cold weather without supplementary heat; when heat was supplied less heat was required and it gave protection against freezing without excessively high temperatures at the top of the load. With greater numbers of cars equipped with fans now available, apple shippers would do well to use them at every opportunity, especially when low temperatures are likely during shipment. When sustained low temperatures are probable, as after the middle of November with shipments across the northern part of the continent, the mechanical circulation of air should be supplemented with heater service. Otherwise, freezing throughout the load may result if the shipment should encounter several days of near-zero weather.

THE DEALER'S RESPONSIBILITY

From what has been said so far, it might appear that the condition and quality of apples are predetermined by what happens to the fruit before it reaches the dealer. This is true in large measure, but there are a number of things that the dealer can do to reduce deterioration of the apples he buys for resale. To list them would be for the most part to repeat the factors already enumerated, but with special application to conditions under the dealer's control.

Apples at proper harvest maturity usually have not reached their highest eating quality. The maximum dessert quality appears after a storage period, the length of which varies with different varieties, stage of maturity at time of harvest, and the storage temperature. After they have reached maximum dessert quality they begin to deteriorate. The longer they are held in storage the shorter will be the marketable life when removed for sale.

The first responsibility of the dealer is to buy good fruit, but this does not necessarily mean buying fruit marked "Extra Fancy" or "U. S. No. 1." These grade designations, even though they may have honestly described the quality of the fruit at the time of packing, do not reflect changes in condition, such as ripeness, decay, and scald, that have taken place during storage. The buyer should have the apples inspected at the time he intends to purchase them in order to determine the extent

to which deterioration has progressed since the apples were graded and packed. Most dealers make such inspections themselves or have the opportunity to do so. Hence, if they buy fruit that is badly bruised, overripe, more or less decayed, misshapen, wormy or scale infested, or cull, presumably they do it with the intent to offer that class of fruit to customers.

The wholesale dealer, in making purchases at shipping point, has the responsibility of ordering the transit protective service. Through either experience or consultation with experienced shippers he should make certain that the protection is adequate for the particular fruit being shipped under the weather conditions that are likely to prevail. Wholesale and retail dealers have a joint responsibility in handling fruit after transit. Serious bruising results every time a box or basket of apples is slapped down on floors, on truck beds, or on other packages. These heavy impacts, which may occur several times after a package has been received at a terminal market, contribute heavily to the number of badly bruised apples reaching the retail bin.

Next to bad bruising, overripeness is the greatest cause of complaint among retail purchasers. A criticism often heard is, "Nice-looking large red apples, but mealy and tasteless." That always means overripe apples. How fast do apples get overripe? The answer depends on the temperature—in the retailer's store as well as in commercial storage or in the hands of the grower after harvest. Apples ripen about twice as fast at 70° as at 50° F., twice as fast at 50° as at 40°, and twice as fast at 40° as at 32° (p. 9). If they are ripe when bought for sale, some kinds (Delicious in particular) can become overripe and mealy in 2 or 3 days at ordinary store temperatures and in even less time if they are piled behind windows for display and are not protected against hot sunshine. The safest procedure for a retail merchant is to regard apples from cold storage late in the season as being as perishable as peaches at the height of their season and to move the apples into consumers' hands before they have a chance to get overripe and out of condition.

Apples purchased in small lots usually cost more than those obtained in large quantity; hence, retailers may buy more than they can dispose of before the fruit gets overripe. Unless refrigeration facilities can be utilized, the merchant who would sell only apples not beyond their prime should obtain fresh stock from cold storage at intervals of not over 2 or 3 days rather than hold a surplus in a warm place. If some of the fruit must be held over, especially during warm weather, the best place to keep the apples is in a refrigerator. Some stores have a special walk-in refrigerator for fruits and vegetables; others utilize space in the meat cooler; and an increasing number of stores are now installing open refrigerated cases with storage compartments below the retail display shelves. If refrigeration is not available, the apples will benefit by being held in a cool, well-ventilated place, perhaps in the stockroom, where screened or barred windows can be left open, or in a cool basement room.

Packed boxes should always be stacked on the side (fig. 15), and never on the top, which is bulged to hold the fruit in place, or on the end, which will concentrate the weight on a smaller area and increase chances of bruising. Only when the top is removed and pressure is released, is it safe to let the boxes rest on the bottom lid. Bushel baskets should be staggered by placing one basket on the edges of two others,

keeping all pressure away from the center of the lids (fig. 5). To provide good air circulation, which is needed to keep the fruit cool in warm weather, containers of apples should be kept away from outside walls and should be placed on a false floor or slatted platform with 3 or 4 inches of air space beneath. These measures will also reduce danger of freezing damage in cold weather.

In displaying apples the fruit should be kept away from potatoes, onions, and other root crops from which they may absorb odors. Apples should also be kept away from wet, green, leafy vegetables that are sprinkled to keep them fresh. The apples themselves should never be sprinkled, as this may stimulate decay. However, apples deteriorate rapidly when exposed in warm, dry air; hence, most of the stock should be kept in the original containers (fig. 21). Displays should not be made near radiators, stoves, or sunny windows, and they should be of such size that they will have to be renewed frequently with fresh stock.

FIGURE 21.—Retail display of apples mostly in their original containers, in which they keep best, and away from potatoes and root crops, from which they may absorb odors, and from leafy vegetables, which are sprinkled to keep them fresh.

Frequently dealers make mass displays of apples, removing them from the containers and piling the fruit in pyramids or otherwise in large lots. This contributes to bruising damage unless very carefully done. In self-service stores, where customers are free to select the fruit that they purchase and where in consequence it may be handled a good deal, the bruising is increased considerably after the apples are put on display. The extent of this damage, of course, varies, but that it may be serious is shown by the conditions observed in one of the stores covered by Crandall in the survey reported by Nold (*19*). Crandall ex-

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amined the fruit in original containers just as it was delivered to the store and also some of the same lots as they were displayed for sale. His findings (table 4) show that, although handling in the store increased the damage considerably, most of the bruising was present when the apples were unpacked.

TABLE 4.—*Condition of apples before they were unpacked and after display for sale*

Variety	Sound in original package	Sound when on display
	Percent	*Percent*
Jonathan	64	54
Golden Delicious	72	48
Baldwin	93	43
Greening	71	56

Crandall's results are in general agreement with those reported by Kross and Slamp (*14*), who made a somewhat similar study in New Jersey. They found that 42 percent of the apples on display in the retail stores they surveyed showed old bruises and only 8 percent had fresh bruises as the result, apparently, of handling in the stores.

If the retailer would give his trade the kind of apples that will stimulate demand, he must consider the variety as well as grade and condition. In order to make even such a rough classification as eating apples and cooking apples, as is frequently done in grocery stores, the dealer needs to know something about the principal commercial varieties so that, for example, Rome Beauty, York Imperial, or even Ben Davis will not be offered as eating apples or Delicious as a good baking apple because it has good size. He also needs to know when each is in season. It is not uncommon to find Jonathans and Winesaps offered together. In the fall only the former could give satisfaction, but in late spring the Winesap would be preferred.

While upward of 200 varieties of apples are grown in the United States, only 15 are commercially important (table 5). Farmers' Bulletin 1883 (*15*) gives more information on apple varieties.

Some of the varieties listed in table 5 are good both for eating out of hand and for making sauce, pie, and other dishes; others are best adapted to one or the other of these uses. Yellow Transparent, for example, is too acid to please most people for eating out of hand, but it is one of the best for making sauce and pie. Delicious, on the other hand, is too lacking in acidity for cooking, but is the leader for the fruit-stand trade.

The character of the flesh of a variety when ripe is an important consideration for all handlers of apples, for, in general, it indicates the susceptibility of the fruit to bruising and how it will withstand handling, especially in bulk or in the retailer's bins. Important in this connection also is the color of the fruit. Apples listed as soft in table 5 are most likely to become badly bruised, while those listed as hard are less likely to be damaged by ordinary handling. Those marked firm are intermediate in this respect. As a rule, varieties that are solid yellow or green

show bruising much more readily than red or striped varieties although actually they may not be bruised to any greater extent. Consequently, they have to be handled much more carefully if the appearance of the apples is not to be affected.

TABLE 5.—*Characteristics of principal commercial varieties of apples*

Variety	Color	Principal use	Flesh when ripe	Marketing season
Yellow Transparent.	Yellow	Cooking	Soft	July to August.
Gravenstein	Striped	Eating and cooking	do	July to September.
Wealthy	Red	do	do	September to December.
McIntosh	do	do	do	September to January.
Grimes Golden	Yellow	do	Firm	Do.
Jonathan	Red	do	do	September to February.
Delicious	do	Eating	do	September to April.
Rhode Island Greening.	Green	Cooking	do	October to March.
Golden Delicious	Yellow	Eating and cooking	do	October to April.
York Imperial	Red	Cooking	Hard	October to March.
Stayman Winesap	do	Eating and cooking	Firm	November to April.
Baldwin	do	do	do	Do.
Rome Beauty	do	Cooking	do	November to May.
Yellow Newtown	Green or yellow.	Eating and cooking	Hard	January to June.
Winesap	Red	do	do	Do.

The marketing season indicated for the varieties in table 5 is the period during which commercial supplies should be at their best. If put on the market earlier the apples are likely to be unsatisfactory either because of immaturity (being picked too soon) or because they have not had a chance to ripen sufficiently. If they are offered later than their normal marketing season they may still be in good condition and may still give consumer satisfaction if they have received exceptional care in handling and storage, but the hazards of their soon becoming overripe or of quick breakdown are greatly increased. Much of the complaint about overripeness in apples is due to their being stored beyond their normal marketing season.

THE INDUSTRY'S RESPONSIBILITY

The most practical approach to the problem of getting good apples to the consumer seems to lie in a close coordination of all elements in the industry to apply good handling methods at all times during the marketing process. Success of any such effort will doubtless require the initiative to be taken by apple producers and shippers. They are not only the most immediately concerned but also have the requisite knowledge and appreciation of the technical requirements for handling the apple. Their business is often tied up closely with apples alone, whereas to others in the trade apples are only one item of merchandise. Success of such an undertaking depends also on sustained industry-wide

cooperation rather than on the sporadic initiative of individuals. It can perhaps best be attained through the specialized organizations that have been set up for the purpose of promoting the sale of apples generally. With adequate support of these organizations by growers and shippers, and close-knit cooperation between such organizations in different parts of the country particularly, much could be done. Success would require an educational or demonstration program based on two fundamentals that apply to all in the industry: (1) The intrinsic worth of the apple as an article of diet and (2) the necessity of keeping apples in good condition to maintain their intrinsic worth as food.

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